Norman Lockyer observatory,
Salcombe Hill, Sidmouth, Eng.
Handbook to the Norman
Lockyer observatory

HANDBOOK TO THE NORMAN LOCKYER OBSERVATORY

1921.

COMPILED BY

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LIST OF ILLUSTRATIONS.

(1) NORMAN LOCKYER

1836–1920

SIR NORMAN LOCKYER, the originator and part founder of the Hill Observatory, was born at Rugby on May 17th, 1836. He was the son of Mr. Joseph Hooley Lockyer, a lecturer on scientific subjects at Rugby, and also one of the early workers on the electric telegraph. His mother, before her marriage, was Miss Anne Norman, of Cosford.

He was educated at private schools and on the Continent, and in 1857 received an appointment at the War Office, where he was later made Editor of Army Regulations. In 1870 he was appointed Secretary of the Duke of Devonshire's Royal Commission on Scientific Instruction and the Advancement of Science. When the work of the Commission was completed, and as a result of his discoveries in connection with the sun and his private astronomical work, he was offered an appointment in the Science and Art Department, South Kensington, by Mr. Disraeli, the Prime Minister, which he accepted and was transferred there in 1875.

Scientific pursuits, however, had long supplied the real interest of his life. While at the War Office his leisure was given over to the study of astronomy, and while there he erected an observatory at his home in Hampstead.

His first observations were on the planet Mars, and he communicated them in 1863 to the Royal Astronomical Society, having been elected a Fellow of that Society two years previously.

In 1860 Kirchoff first demonstrated the possibility of determining what substances the sun and stars were made of by the light which came from them. Lockyer soon realised the significance of these revelations in physical astronomy, and turned his attention at once to the application of the spectroscope to the celestial bodies. From that time onward his observations were brilliant and epoch making, and he was soon (1869) made a Fellow of the Royal Society and afterwards (1875) a Corresponding Member of the Paris Academy of Sciences. The discovery in 1868 of the gaseous nature of solar prominences, simultaneously with the great French astronomer Janssen, on which occasion the French Government struck a special medal, and the further discovery in the same year of the gas helium in the sun, found on the earth by Sir William Ramsay twenty-seven years later, are only two of the many striking advances which he made.

On his appointment as Professor of Astronomical Physics in the Royal College of Science and later, 1885, as Director of the Solar Physics Observatory, South Kensington, he was in a position to carry on, unhampered by other official work, his investigations in solar and celestial physics. The results of these researches have been embodied in his numerous books, which include "Contributions to Solar Physics," "The Spectroscope and its Application," "Studies in Spectrum Analysis," "Stargazing : Past and Present," "Chemistry of the Sun," "Meteoritic Hypothesis,"

"The Sun's Place in Nature" and "Inorganic Evolution."

He was chief of no less than eight British Government Solar Eclipse Expeditions, and organised the programmes of several others while Director of the Solar Physics Observatory.

On the transference of the Solar Physics Observatory to Cambridge in 1913, when his official connection with the Observatory ceased, he felt the abrupt break in his life's work very deeply. Being as keen as ever on the progress of astrophysics he devoted himself to erecting this Hill Observatory at Sidmouth, where he spent his declining years. The progress made in the buildings, equipment and organisation under his care will be found described in the body of this Handbook.

In addition to his astronomical work he originated and edited the now well-known scientific journal called "Nature" from the year of its foundation in 1869 up to 1919.

His public activities made contact with national life at many points, and he set himself the task of establishing an organisation which would bring home to all classes of the community the necessity of making the scientific spirit a national characteristic to inspire progress and to determine policy in affairs of all kinds; as a result the British Science Guild was founded in 1905.

During his career he received many distinctions. As early as 1871 he was appointed Rede Lecturer to Cambridge. The Royal Society awarded him the Rumford Medal in 1874 and appointed him Bakerian Lecturer for the same year and again in 1888. Glasgow, Edinburgh and Aberdeen gave him the honorary degree of LL.D.; Cambridge and Sheffield the Hon. Sc.D.;

Oxford the Hon. D.Sc. The British Association elected him as President for 1903–4. In the year 1894 he was given the C.B., and in 1897 he was promoted to K.C.B. He was also a member of many learned societies both in this country and in France, Germany, Italy and the United States.

He was twice married. His first wife, who died in 1879, was the younger daughter of Mr. William James, the well-known engineer, of Trebenshon, near Abergavenny, by whom he leaves four sons and two daughters. In 1903 he married the younger daughter of the late Mr. Samuel W. Browne, of Bridgwater and Clifton, and the widow of Bernard E. Brodhurst, F.R.C.S.

In concluding this brief sketch of a most active life it is fitting to quote the following extracts from the address of the President of the French Academy of Sciences, Monsieur Henri Deslandres, the distinguished astronomer, one of the Foreign Members of the Norman Lockyer Observatory, delivered at the opening meeting of the Session of the Academy, on October 4th, 1920 :—

Monsieur Deslandres said :—

" During the holidays the Academy has had the grief of losing one of its most illustrious correspondents, the great English astronomer, Sir Norman Lockyer . . ."

" Sir Norman Lockyer is one of the founders of Physical Astronomy, which has developed so greatly during the last 50 years. He approached Science by untrodden paths, and great discoveries are associated with his name . . . ."

" Sir Norman Lockyer is certainly one of the greatest scientific men of England, and one of the greatest astronomers of all time. The Academy is honoured by his inclusion as one of its members."

Fig. 2.—LIEUT.-COL. F. K. McCLEAN, A.F.C.

From a Photograph by
FOULSHAM & BANFIELD, Ltd., London.

(2) The Object of an Astronomical Observatory.

The object of an Astronomical Observatory is to make a study of the appearances, compositions and movements of the heavenly bodies in order to further our knowledge of what exists and is happening in the realm of space surrounding the little earth on which we dwell.

To accomplish this instruments of various kinds are used, and the more powerful these are the greater is our knowledge advanced.

Thus, transit instruments fix for us the positions of the stars around us, and tell us of some of their movements in space, and the latter can only be accomplished after many years of continuous observations. Telescopes, whether of the refracting or reflecting kind, show us what the celestial bodies look like, and small adjuncts to these instruments reveal to us the internal movements of systems or stars which abound in space.

The attachment of glass or quartz prisms to telescopes help us to extend our knowledge in two other directions, for not only is it possible to determine the motions of stars which cannot be detected by the telescope alone, but a means is afforded us of finding out exactly what the celestial bodies are made of, and an approximate idea can be gathered as to their temperature and density.

The advent of the photographic plate has revolutionised the whole of observational astronomy, for where formerly hours were required to make a few observations the photographic plate is capable of recording in a few minutes a vastly greater host of facts than was possible formerly.

Further, it is possible to photograph objects in the heavens which the eye of man will never be able to see, and it is for this reason that photography has given us a far grander idea of the extent of the universe than we should have otherwise secured.

(3) Favourable Conditions for an Observatory.

It is obvious that an astronomical observatory should be located in a region where the heavens can be viewed to the very best advantage, and it is as well to consider in the first instance what the most favourable conditions should be.

First of all, it must not be forgotten that the light of the heavenly bodies, before it reaches the object glass of the telescope, has to pass through our atmosphere, and this atmosphere is always in a state of movement, and absorbs some of this light during its passage. It is advisable therefore to get rid of as much of this atmosphere as possible, and this is accomplished by placing the observatory as high above sea level as possible.

The ideal position is that situated on a very elevated plateau and mountains if possible should be avoided, as they facilitate the formation of local air currents unless they are heavily wooded or covered with verdure. Again the fewer clouds there are the greater is the opportunity for observation, so climatic considerations are very important.

Other detriments to good observation or " seeing," as it is termed, are mists, smoke, traffic tremors, town night-glare, etc., and good sites should be as free as possible from these.

It will be seen therefore that when it is desired to erect a new observatory such conditions as enumerated above ought to be adhered to as far as possible. Further, the site should be so chosen that the required conditions would be permanent, *i.e.*, that towns, railways, trams, etc., are not likely in the future to be placed near the locality.

In order to find out whether a site is favourable for an observatory, observations of the sun by day and stars by night should be undertaken.

Should the enlarged image of the sun formed by a telescope be found to be " steady " and the definition of a sun-spot be good and maintain this quality, then the day " seeing " is said to be satisfactory. In the case of night observations a star's image in the telescope is put out of focus and a series of rings are formed round the central point. If these rings rapidly change their shape or merge into one another, the " seeing " is bad, but if on the other hand they maintain their figure steadily, then the night " seeing " is considered good.

It has been the habit at this Observatory on nearly

every night of observation to record the appearance of those diffraction rings, as they are called, and the result shows that the "seeing" is as a rule very good.

Towards the end of the year 1920 Mr. John Evershed, F.R.S., the Director of the Solar Physics Observatory at Kodaikanal, S. India, and an expert on the question of "seeing," visited the Observatory and tested the day "seeing" at midday in the above-mentioned manner. The conclusion he came to was that it was very good, very much better, in fact, than the average conditions at his observatory at the same time of day.

There seems little doubt that the gorse, bracken, grass and other vegetation with which the Observatory site and neighbourhood is covered prevents the sun from over-heating the ground to any extent, and thus detracts from the formation of local convection currents which are usually associated with elevated bare sites and are undoubtedly the cause of bad definition.

(4) Elevated Sites for Old and New Observatories.

It is instructive to glance back a moment to the locations of some of the old-established observatories of the world and to note that while their observing conditions may have been satisfactory when they were founded they are not considered so now. Thus the following list shows how some of these institutions

have either migrated or have added a new outstation to their establishment :—

	Height of Old Site. ft.	Height of New Site. ft.
Paris (Meudon)	194	534
Sicily (Mount Etna)	155	9,735
Berlin (Potsdam)	122	318
Madras (Kodaikanal)	23	7,745
Washington (Mount Weather) ..	200	1,725

More recently erected Astrophysical and Solar Observatories equipped with large instruments have been placed at high stations, as will be seen from the following list :—

		Elevation. ft.
Yerkes Observatory	Lake Geneva, nr. Chicago, U.S.A.	1,105
Lick ,,	Mt. Hamilton, Cal., U.S.A. ..	4,209
Mt. Wilson ,,	Mt. Wilson, Cal., U.S.A.	5,712
Lowell ,,	Flagstaff, Arizona, U.S.A. ..	7,293
Montgros ,,	nr. Nice, France	1,240
Dominion Astrophysical ,,	Victoria, Canada	730

(5) The Beginning of the Norman Lockyer Observatory.

In the year 1909 the Solar Physics Observatory at South Kensington had become so surrounded by large buildings that it was decided to remove it to another site. That Observatory, where astrophysical and astrochemical work had been carried on continuously since 1875 under its distinguished originator and director, Sir Norman Lockyer, and the work at which

had been a model for so many other observatories, was eventually transferred to Cambridge.

On his retirement Sir Norman Lockyer felt that if England was to retain the position she had won for herself in this branch of astronomy, it was essential that a hill observatory should be established where this work could be carried on under the best available conditions.

Having recently built a house on Salcombe Hill, and procured land which extended up to and on the top of this hill, he was led to consider the last-mentioned site as an excellent one for an observatory. The position seemed admirably suited for the purpose, although it was not originally chosen with this object.

With his undaunted energy he set about constructing the Observatory in 1912, and with the help of sympathetic friends formed an advisory and organising committee on the various technical subjects which had necessarily to be studied while the building and equipment were proceeding.

The first organised meeting was held on July 8th, 1912, those present being as follows :—

Sir William Abney, K.C.B., F.R.S.
Prof. O. Backlund.
Prof. A. Bélopolsky.
Sir William Crookes, O.M., F.R.S.
Sir David Gill, K.C.B., F.R.S.
Charles Hawksley, Esq., M.I.C.E.
Sir Norman Lockyer, K.C.B., F.R.S.
Lady Lockyer.
Dr. W. J. S. Lockyer, M.A., F.R.A.S.
W. N. McClean, Esq., F.R.A.S.
Prof. J. Perry, F.R.S.
Sir William Ramsay, K.C.B., F.R.S.
Dr. W. N. Shaw, F.R.S.
Sir Aston Webb, K.C.B., C.V.O., R.A.

Sir Norman Lockyer was elected Chairman, and

stated how the idea of a Hill Observatory had originated in a conversation between Mr. F. K. McClean and himself.

Organising and advisory committees controlled the Observatory, and in June, 1914, submitted a draft of incorporation. Owing to the war this incorporation did not take place until 1916.

The appeal for funds, under the presidency of H.R.H. Prince Arthur of Connaught, was started in February, 1913, and was supported by the following Vice-Presidents and Committee :—

Vice-Presidents.

H.H. The Maharajah of Jhalawar.	Sir John Wolfe Barry, K.C.B., F.R.S.
Rt. Hon. Lord Blyth.	Rt. Hon. Sir William Mather.
Rt. Hon. Lord Tennyson, P.C., G.C.M.G.	Sir Lauder Brunton, Bart., F.R.S.
Sir Philip Magnus, M.P.	F. Fry, Esq., J.P.
Sir Boverton Redwood, Bart.	Sir Isidore Spielmann.
Sir William Turner, K.C.B., F.R.S.	Lady Trevor Lawrence.
	Rt. Hon. Lord Southwark.
Sir William White, K.C.B., F.R.S.	Dr. Edward Hopkinson.
	Colonel Giffard.

Chairman	Sir David Gill, K.C.B., F.R.S.
Hon. Treasurer	Rt. Hon. Lord Avebury, F.R.S.
Hon. Assistant Treasurer ..	Lady Lockyer.
Trustees	Sir Edward Busk, Robert Mond, Esq., W. N. McClean, Esq., G. M. Seabroke, Esq.,
Hon. Secretary	W. N. McClean, Esq.

Members.

Sir William Abney, K.C.B., F.R.S.	Major O'Meara, R.E., C.M.G.
	Prof. J. Perry, F.R.S.
Sidney G. Brown, Esq., F.R.S.	Sir William Ramsay, K.C.B., F.R.S.
Sir William Crookes, O.M., F.R.S.	
	Dr. W. N. Shaw, F.R.S.
Prof. A. Fowler, F.R.S.	Alexander Siemens, Esq.
Provost Gregory Foster.	Sir John Thornycroft, F.R.S.
Charles Hawksley, Esq.	Sir Philip Watts, K.C.B., F.R.S.
Dr. W. H. Maw.	Sir Aston Webb, K.C.B., R.A.

Help in forming the Observatory was not confined to home members only, for the names of several distinguished foreigners were eventually added. These were as follows :—

PROF. O. BACKLUND,
Pulkowa Observatory.
PROF. A. BÉLOPOLSKY,
Hill Observatory, S. Russia.
M. DESLANDRES,
Meudon Observatory.
PROF. E. B. FROST,
Yerkes Observatory.
DR. G. E. HALE,
Mt. Wilson Observatory.
PROF. PERCIVAL LOWELL,
Flagstaff Observatory, Arizona.
PROF. E. C. PICKERING,
Harvard College Observatory.
PROF. A. RICCO,
Mt. Etna Observatory.
DR. R. S. WOODWARD,
President, Carnegie Institution,
Washington.

Apart from gifts of land, to which reference will be made later, it is quite obvious that no immediate progress in the equipment and maintenance of the Observatory could have been made without an immediate donation of money and instruments. For this purpose Sir Norman Lockyer and Mr. F. K. McClean put forward the necessary money to construct the buildings which are on the present site, and further with Lady Lockyer guaranteed considerable sums of money for several years.

These handsome donations were followed up by other friends with sums of money of varying amounts which enabled the Observatory to be maintained for several years. Amongst those who have given sums of over ten guineas are the following :—

ROBERT MOND, ESQ., F.R.S.E.
CAPTAIN W. N. MCCLEAN.
MARRIOTT PARKINSON, ESQ.
RT. HON. SIR W. MATHER, P.C.
CHARLES HAWKSLEY, ESQ.
PROF. PERCIVAL LOWELL.
MRS. LUDWIG MOND.
MISS GREGG.
H.H. THE MAHARAJAH OF JHALAWAR.
FRANCIS FRY, ESQ.
MISS ANNA MCCLEAN.
SIR PHILIP WATTS, K.C.B., F.R.S.
SIR JAMES CAIRD.
MISS LEIGH BROWNE.
DR. W. H. MAW.

In addition to the very large donation of valuable

Fig. 3.—**The Region around the Norman Lockyer Observatory.**

The small dark area is the site of the Observatory.

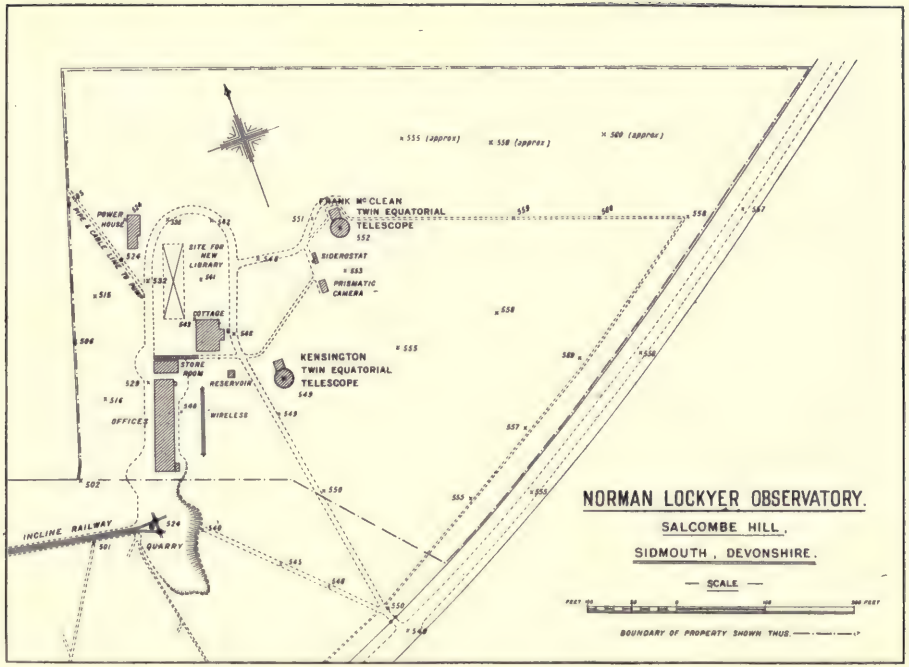

Fig. 4.—**Plan of Site.**

instruments and apparatus presented by Sir Norman Lockyer and Mr. F. K. McClean, a list of articles too large to print here, gifts by other donors, were as follows :—

Sir David Gill	Sidereal Chronometer (D. Gill & Sons No. 1).
Lt.-Col. W. A. J. O'Meara	Wireless receiving apparatus specially adapted for the Eiffel Tower Signals.
Sidney G. Brown, Esq., F.R.S.	Wireless telephone relay; adjustable condenser; fixed condenser; milliamperemeter; transformer; two wireless telephone head pieces; crystal detector.
Alexander Siemens, Esq.	Dynamo and belt.
Dr. J. A. Harker ..	Small electric furnace.
Robert Mond, Esq. ..	Electric motor and accessories for driving three-throw water pump.

With the above assistance of gifts of money and instruments the Observatory began its career, and observational work was commenced with one instrument in the year 1913.

In the year 1916 the Observatory was formed into a Corporation, to promote its development. All the lands, buildings and equipment were conveyed to this body, to which further reference will be made later (page 31).

(6) The Present Site.

The site of the Observatory (latitude 50° 41′ 30″ N., longitude 3° 12′ 40″ W.), which was presented by Sir Norman and Lady Lockyer, is excellently situated on the top of Salcombe Hill, overlooking Sidmouth, at a height of 560 feet, and possesses an unbroken horizon

in every direction. It is well away from traffic tremors and night glare, and will always retain those advantages, the contour of the hill near the top being unsuitable for the erection of many dwelling houses. It is thus eminently suited to the objects in view, and the results which have been obtained up to the present have fully justified the choice of the position. It is free from the occasional low-lying mists of the adjacent valleys, which rarely cover the top of the hill at night-time, and the purity of the sky on a cloudless night is extremely good. On the land are gravel quarries, which have allowed of the buildings being constructed of concrete blocks made on the spot. The site is shielded by the massif of Dartmoor from the full south-westerly and westerly gales and heavy rains, and the "seeing," as mentioned before, is excellent.

When approaching Sidmouth on the Exeter Road, a splendid view of the site is obtained across the Sid Valley. The lie of the ground is rather extraordinary, as the high ground forms a plateau or table-land at an elevation of about 600 feet, the top being a gravel deposit horizontally bedded on the green-sand, which, in its turn, is horizontally bedded on the new red sandstone.

The observing instruments are situated on the flat summit, while the offices, laboratories, etc., have been erected just below the summit, thus interfering in no way with the horizon of the telescopes. The one-storey buildings on the gorse and heather-topped hill by no means disfigure it: their dull red ruberoid roofs harmonise with the general colouring, and the domes alone break the sky-line.

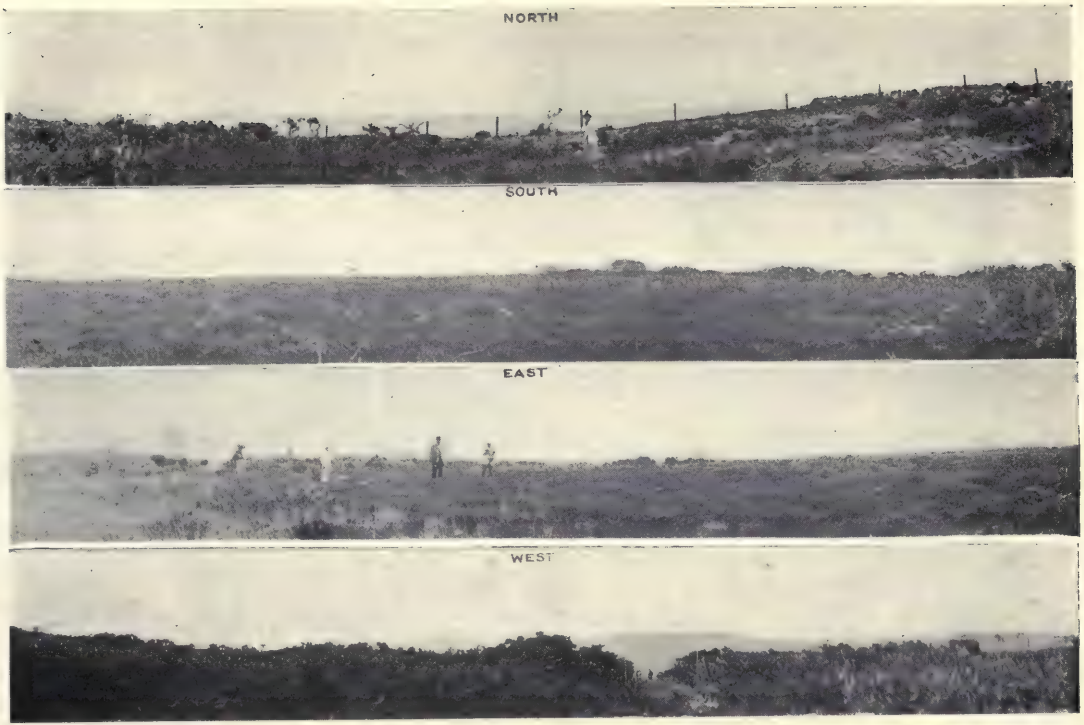

Fig. 5.—Panoramic View of the Horizon from the Site of the Observatory.

Fig. 6.—**Offices and Terrace, looking North.**

The site has an extent of about seven and a half acres, including a portion at a much lower level in which the springs, filter-bed and pump are situated. An additional piece of land to extend the northern boundary was very kindly presented by Miss Leigh Browne.

(7) The Buildings.

A QUARRY, started originally to supply the material for Sir Norman Lockyer's house, which lies about 300 feet below the summit, is situated on the west side of the hill close to the top, and a short wire rope incline railway runs from this quarry to a road below. The quarry, which contains flints, gravel and some sand, has provided the materials for the concrete and for the road metal; the nature of the ground has thus contributed, and will in the future contribute, in no small way to economical building.

The foundation is absolutely solid and is practically a natural concrete. Most of the buildings are of concrete, some in the form of blocks made on the site.

(A) The Offices.

The offices face the terrace along the side of the hill overlooking Sidmouth, and with a splendid view of the coast as far as Scabbacombe Head a few miles further than Berry Head. This terrace faces west,

and at its southern end is the quarry and top of the incline railway. On the roadway have been mounted natural blocks of conglomerite which have been moved from other parts of the site.

This building is constructed of cemented flints with roof of ruberoid and covers an area of 104 by 21 feet. It is divided into five rooms each 20 by 20 feet, and used as director's room, spectroscopic laboratory, library and wireless, photographic room, and workshop. The whole is heated by hot water from a furnace in a sunken lean-to chamber.

The rooms in the offices are generally known by numbers, one to five, number one being that at the southern end of the building. Number one room is the registered office of the Corporation and the director's room.

Room number two is devoted to experimental work, and contains electrical and spectroscopic apparatus for research work. A 12-inch siderostat is mounted in a small hut outside on the terrace for the purpose of obtaining sunlight for use in the spectroscopes.

Number three room is at present used as a library, but it is hoped that in the near future a new and separate building will be constructed for that purpose. A valuable research library is in rapid progress of formation, Sir Norman Lockyer having presented the whole of his astronomical library, and Lieut.-Colonel F. K. McClean a great number of valuable books and pamphlets. To deal with these six additional double bookcases were obtained, as the space provided was far from sufficient.

An exchange of publications between this and

Fig. 7.—Interior View of the Offices, showing the Library (nearest room), Laboratory, and Director's Room.

Fig. 8.—**A Corner of the Spectroscopic Laboratory.**

Fig. 9.—**Apparatus for receiving Wireless Time and Weather Signals.**

Fig. 10.—**View from Frank McClean Dome, showing Siderostat in foreground and Porter's Lodge.**

other observatories and institutions has been in operation some time, and this not only keeps the library up to date, but necessitates preserving considerable room for expansion of book space.

The clocks and wireless receiving apparatus are also installed in this room, the aerials for the latter being outside on the higher ground to the eastward. This apparatus is used for the receipt of weather and time signals.

Number four room is devoted exclusively to photography and contains a dark room, an enlarging room, and also a copying camera mounted on a wooden base. Brackets are placed outside the windows for supporting a large glass mirror to supply sky light to the enlarging and copying cameras.

Room number five is fitted up with a carpenter's and fitter's bench together with a foot lathe.

(*B*) *Store Room.*

This room is used for the storage of packing cases, ground tools, etc., and has a lavatory attached. It covers an area of 30 by 20 feet.

(*C*) *The Power House.*

This building (40 by 15 feet) is divided into two rooms, the engine being situated in one and the set of accumulators in the other. The engine consists of a 12 horse-power Crossley oil engine. It drives by means of a belt a Siemens' dynamo for charging the 60 Tudor batteries in the adjoining room. The

current that is transmitted is 110 volts, and is used for lighting, pumping and laboratory purposes. The dynamo and belt were presented by Mr. Alexander Siemens, and the former was so constructed that it can operate the electric furnace which is used in the spectroscopic room for research work.

(*D*) *The Porter's Lodge.*

This bungalow is a single-storey house with its roof on the level of the top plateau. The rooms consist of a kitchen, scullery, three bedrooms and a sitting room. At the present time part is used as an overflow from the library.

(*E*) *The Frank McClean Dome.*

The Frank McClean Dome consists of a circular building 20 feet in diameter, the walls of two shells of 4·5 in. blocks with an air space of two inches between them. The roof, designed by Captain W. N. McClean, R.E., is hemispherical in shape and made of wood covered with ruberoid with movable shutters, the whole being mounted on wheels running on rails. Adjoining is the annexe and photographic room. The dome contains a twin telescope presented by Lieut.-Colonel F. K. McClean. They are both refractors, having object glasses of 12 inches and 10 inches. The former is fitted with a 12-inch prism of 20° angle, and another prism of 12 inches and 15° angle is available when required. This telescope has a camera attachment, and is used for photographing the spectra of

Fig. 11.—Showing the Frank McClean Dome on the right and the Kensington Dome on the left. View looking S.W.

Fig. 12.—**Frank McClean Dome and Telescope, looking West.**

the fainter stars. The 10-inch telescope is for visual observations only. The instrument is fitted with a Grubb electric control and pendulum and electric illumination for the declination circle.

This instrument was originally built for the late Frank McClean, F.R.S., and erected at his house at Rusthall, Tunbridge Wells. With it he made a very detailed survey of the spectra of the brighter stars in the Northern hemisphere, and published an important volume setting forth a classification of the stars he photographed. At a later date he took the prism to the Royal Observatory at the Cape and fixed it on to an equatorial there, where he made a similar survey of the Southern stars of magnitude 3·5 or brighter. The surveys which he made are now being continued on Salcombe Hill and extended to stars as faint as magnitude 6.

An example of some of the work recently accomplished with this instrument is referred to in §9, page 26.

(*F*) *The Kensington Dome.*

The Kensington Dome consists of a circular building 20 feet in diameter, the walls being formed of concrete blocks made hollow so as to act as a double wall. The roof, also designed by Captain W. N. McClean, R.E., is hemispherical in shape and made of wood covered with ruberoid with movable shutters, the whole being mounted on wheels running on rails. The annexe adjoining contains also a dark-room. The dome contains another twin telescope consisting of a 10-inch refractor for visual purposes only and a 9-inch

refractor with a prism of 9 inches aperture and 45° angle. The latter instrument is fitted with a camera attachment, and is used for photographing the spectra of the brighter stars. The instrument is fitted with electric illumination to the Declination circle, and its motion is controlled by Russell's electric control.

(*G*) *The* 21-*inch Siderostat.*

The 21-inch siderostat building consists of two small huts. One is made of wood with a ruberoid roof running on rails to cover the instrument. The other is of concrete, and partially sunk in the ground with a ruberoid roof and movable shutters. This was the first instrument mounted and used at the Observatory as it was more easily erected than either of the large equatorials. The instrument was worked in conjunction with a 9-inch prismatic camera, and numerous photographs of stellar spectra were taken. It was put up chiefly for experimental purposes but has been dismantled, and the prismatic camera is now erected on the Kensington equatorial. This siderostat was specially built for Lieut.-Colonel F. K. McClean, by Messrs. T. Cooke and Sons, of York, and was used by him for the total solar eclipse expeditions to Flint Island (1908), Tasmania (1910), and Tonga Islands (1911).

(*H*) *The* 30-*inch Reflecting Telescope.*

In addition to the astronomical instruments enumerated above the Observatory is in possession of

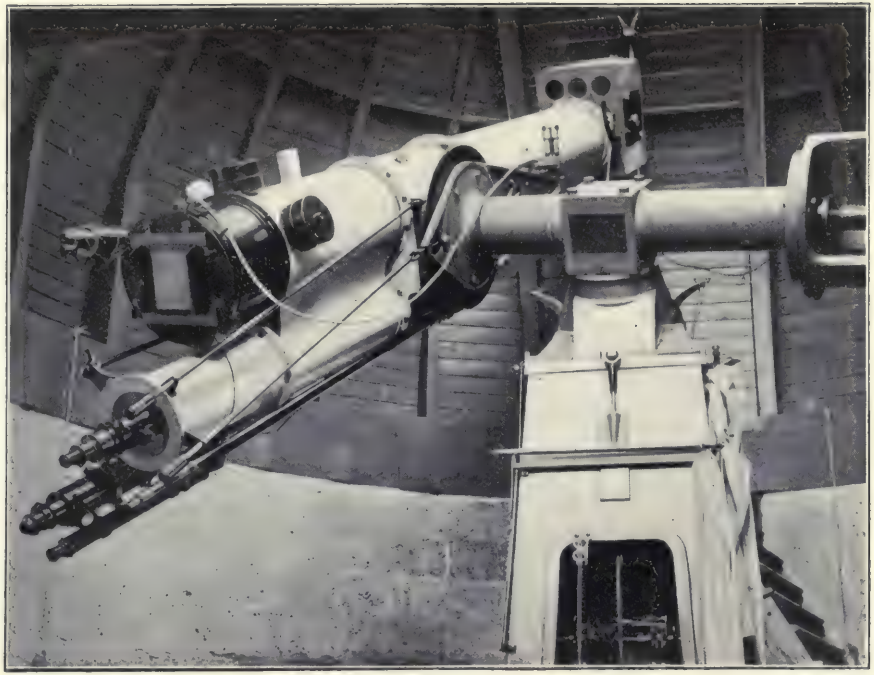

Fig. 13.—**Interior View, showing Eye End and Mounting of the Frank McClean Telescope.**

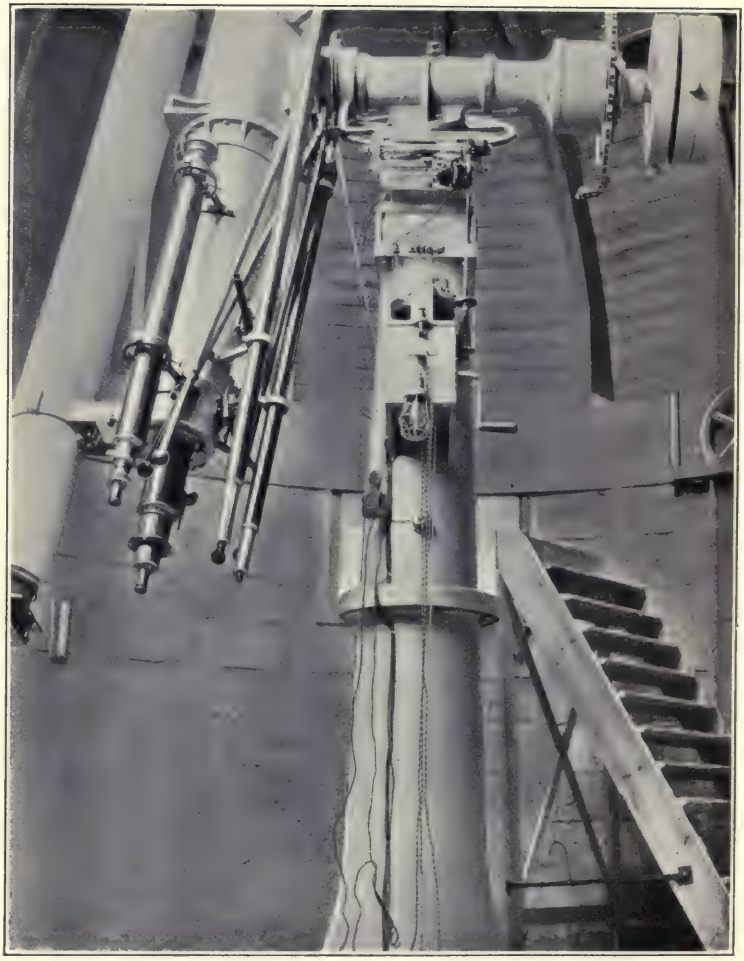

Fig. 14.—**The Kensington Twin Equatorial. The 9-inch Prismatic Camera is the tube on the left, the 10-inch Refractor being a little to the right.**

a large reflecting telescope presented by Sir Norman Lockyer. This instrument has been previously in use at Westgate-on-Sea, Thanet, and at South Kensington. It consists of a 30-inch mirror made by Common and a 7-inch flat, and is complete with mounting and clock. It was hoped to have erected the instrument in 1914, and His Royal Highness Prince Arthur of Connaught, together with the Princess, honoured the Observatory by cutting the first sod for the selected site ; but the war intervened, and the Observatory for this telescope is still not erected.

(J) The Pump House.

The pump house consists of a small corrugated iron building, and is situated at the springs about 200 feet below the site of the Observatory. It contains a three-throw pump worked by hand or by an electric motor, the source of power being at the power house on the Observatory site.

(8) Water Supply.

At the foot of the green-sand many springs issue, giving a good supply of water during summer and winter alike. One of these springs is led into a reservoir through a filter bed, and this is pumped up electrically into a concrete tank sunk into the ground on the summit. Thence the water is supplied by gravity to

the offices and other buildings. This supply is ample for all requirements, but, in addition, rainwater is collected from the roofs. Mr. Robert Mond kindly provided the funds for the electric motor and the necessary connections from the pump to the power-house.

(9) Programme of Work of the Observatory.

THE routine work carried on in the Observatory is in the main spectroscopic. As the word "spectroscopic" may not be generally understood a few words as to its meaning may not be here out of place.

If white light, such as sunlight for instance, be made to pass through a prism of glass or quartz, or be allowed to fall on the surface of a diffraction grating, it is broken up into its component parts, giving what is known as a spectrum. From this spectrum it is possible to tell the kinds of materials which are being burnt up or vaporised at the source of the white light. Thus it is quite an easy matter to say what materials the stars are made of, for one has only to place a prism in front of the object glass of a telescope and replace the eyepiece by a camera, and thus photograph the spectrum of a star. The main work of the observatory consists in photographing the spectra of the stars and classifying them according to their chemical composition and temperature, for it is found that there are large differences between

Fig. 15 T.R.H. Prince and Princess Arthur of Connaught cutting the first sod for the site of the Connaught Dome, April 21st, 1914.

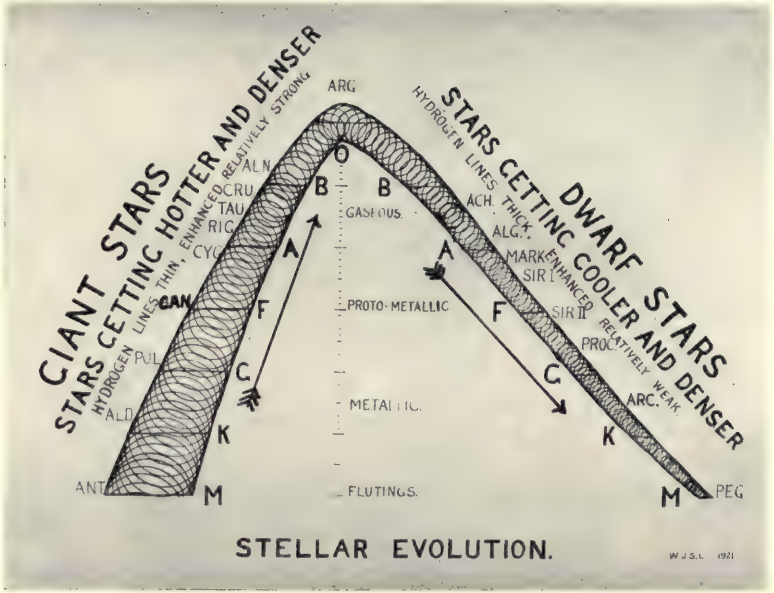

Fig. 16.—**A Curve to illustrate the life histories of Stars from their birth (left hand side) to their death (right hand side).**

the spectra from star to star. It was after a considerable study of stellar spectra that Sir Norman Lockyer was the first to point out that stars could be divided into two main groups, one set increasing their temperature and the other decreasing or cooling, and on this basis he placed the stars in consecutive stages of evolution. This system of classifying the stars has recently been corroborated by Professor H. N. Russell, Director of the Princeton Observatory, one of our foreign members, who studied the subject from quite a different standpoint, and it is now almost universally accepted. The accompanying figure (fig. 16) gives one a general survey of the process.

At the beginning of the sequence the stars are of great size, of little density and of a red colour, and called "Giant" stars. As they get hotter they gradually contract, become more dense and take on a yellow colour. At the top of the curve they have reached their maximum temperature and are bluish green, and then commence to cool. As they cool they become more dense and therefore smaller in volume and finally reach a very dense stage at the bottom of the curve (on the right-hand side) and become red again. They have now developed into "dwarfs." It will thus be gathered that stars on the same horizontal level have the same temperature and show nearly the same spectrum, but on the left side they are getting hotter and are giants, while on the right-hand side they are cooling and are dwarfs.

The work of the observatory is now to continue this scheme of classification and apply it to the faintest stars that can be photographed with the available instrumental equipment. The Frank McClean

telescope is engaged on this work and has been in continuous use since its erection for this purpose except for the break of over two years during the war, when no assistant was available to work the instrument.

The appearance of a new star in 1920 presented an opportunity of studying the changes of spectrum which took place, and a valuable series of photographs was secured extending over several months.

Another line of research taken up was one suggested by the American astronomer, Prof. W. S. Adams, of the Mount Wilson Observatory, one of the foreign members of the Observatory Corporation. This consisted in deducing the distances of certain classes of stars from an examination of their spectra. The work was suggested as the Observatory had already accumulated a large number of spectra of stars, and they could be utilised for this research.

In addition to the above the spectra of stars which show unusual or peculiar characteristics, comets, nebulæ and other interesting objects are photographed and discussed as occasions arise.

To illustrate the kind of photographs which are obtained with a telescope having a prism in front of the object glass, an instrument generally termed a " prismatic camera," the accompanying plate (fig. 17), kindly loaned for this purpose by the Council of the Royal Astronomical Society, is here reproduced. This illustration represents a few of a large number of spectra taken with the Frank McClean telescope. The spectra are those of the new star which was discovered on August 20th, 1920, by Mr. F. Denning, of Bristol. No less than 70 photographs were secured,

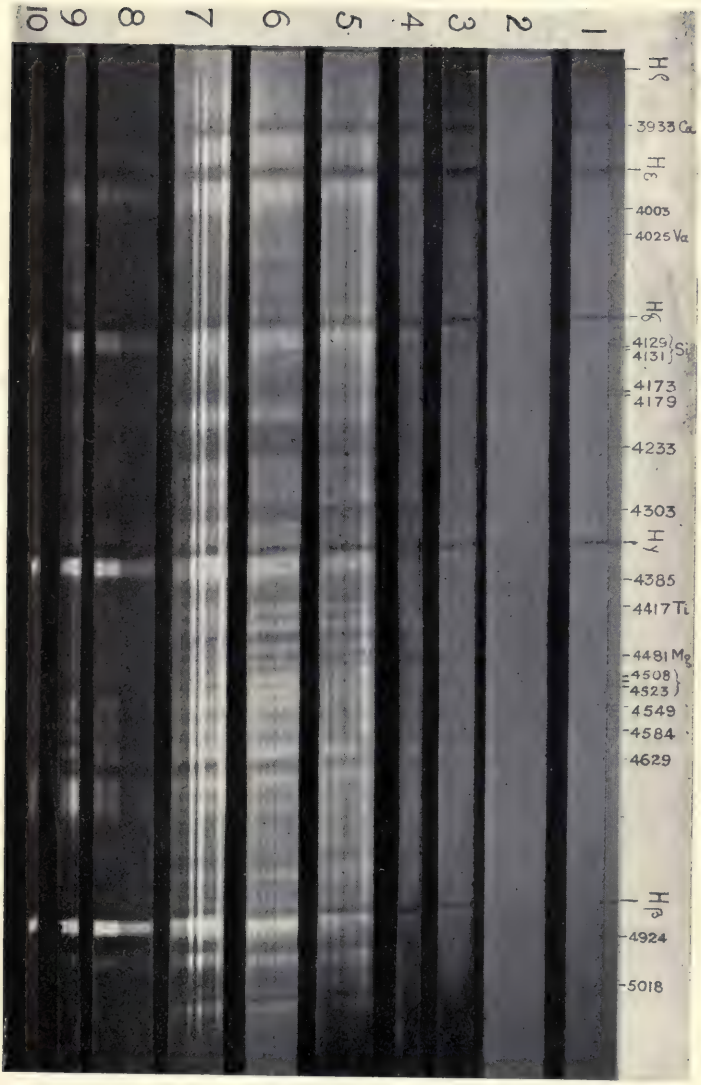

Fig. 17.—**Progressive Spectra of the New Star in Cygnus (1920).**

making a valuable series for studying the changes which the "nova" underwent during the few months of its visibility. At the top is a spectrum of a star called Alpha Cygni, and this shows how closely the "new star" or "nova" resembled it. The great changes which the spectra underwent as the star waned are well shown in the sequence of spectra. It will be seen that the spectrum in the early stages was composed of dark absorption lines, while later these lines were accompanied by bright lines on their right-hand sides, and eventually the dark lines disappeared altogether. The numbers on the left-hand side of the figure represent photographs taken on the following dates :—

No. 1, Alpha Cygni, August 26th, 1920 ; No. 2, Nova, August 22nd ; No. 3, Nova, August 22nd ; No. 4, Nova, August 24th ; No. 5, Nova, August 25th ; No. 6, Nova, August 26th ; No. 7, Nova, August 28th ; No. 8, Nova, September 10th ; No. 9, Nova, September 18th ; No. 10, Nova, September 23rd.

(10) The Staff.

When the Observatory first commenced work in April, 1913, the staff consisted of Sir Norman Lockyer, Director ; Dr. W. J. S. Lockyer, Chief Assistant ; and Mr. H. E. Goodson as Assistant, and an observatory attendant. In August, 1914, Mr. N. K. Johnson was appointed as an additional assistant. In April, 1915, Mr. N. K. Johnson resigned, having received a

commission in the Royal Flying Corps, and in July of the same year Dr. Lockyer left the Observatory, having also received a commission in the Royal Naval Volunteer Reserve. Mr. H. E. Goodson remained at the Observatory until September, 1916, when he left for munition work. The Observatory was then automatically closed, Mr. Lake, the attendant, looking after the instruments and buildings.

It was not until May, 1919, that work was recommenced, Mr. D. L. Edwards having been appointed as assistant after demobilisation from the Royal Engineers. Major Lockyer, after demobilisation from the Royal Air Force, took up his duties again in August of the same year.

Owing to the lamented death of the Director on August 16th, 1920, Major Lockyer acted as Director, and in February, 1921, he was appointed Director, with Mr. Edwards as Chief Assistant.

(11) Research Students.

It is hoped that the presence of this Observatory in the South-west of England will attract from time to time astronomical students from some of the Universities. An opportunity is thus afforded for those students who are desirous of carrying out some research at an observatory to take advantage of the instrumental equipment that can be placed at their disposal. One such student has already attended daily for several weeks, and benefited both himself and the Observatory.

(12) Publications.

THE publication of the research work is printed in the form of Bulletins, and six of these have so far been issued. These relate chiefly to discussions in relation to the classification of stars and catalogues of stars which have been photographed at the Observatory and classified. A publication in hand is one relating to the observations of Nova Cygni III. (1920). Several papers have been read before and published by the Royal Astronomical Society in their Monthly Notices.

(13) Visitors.

WHILE the staff is so small it has only been possible to open the Observatory to visitors one afternoon in the week, namely, Wednesday. In spite of this, a great number of people have visited the Observatory. It is hoped at a later date, when more assistance is available, to devote one instrument for one night a week regularly to show the more interesting objects in the night sky.

(14) The Norman Lockyer Observatory Corporation.

IN a previous paragraph (p. 17) it was stated that the Hill Observatory was formed into a Corporation. It is proposed here to refer to the Corporation more fully.

The licence was granted on July 25th, 1916, by the

Board of Trade to the Corporation under the Companies (Consolidation) Act, 1908, and the Memorandum and Articles of Association were distributed to the members. Under the Memorandum of Association every member is liable to an amount not exceeding £1 to meet the debts and liabilities in the event of winding up. The incorporation has been on democratic lines, and no special powers of management attach to the donors. The membership is fixed at 300, and entails a subscription of £1 1s. a year or a £10 donation. Every member before election must sign a consent form, and has one vote, and only one. General meetings are held annually at which the Officers and Council are elected. The registered office of the Corporation is fixed at the Norman Lockyer Observatory, Salcombe Hill, Sidmouth, Devonshire. The following is the composition of the present Council (1921), in which are vested the management and control of the Observatory.

COUNCIL.

SIR RICHARD A. GREGORY, *Chairman.*
RT. HON. LORD AVEBURY, *Hon. Treasurer.*
S. G. BROWN, ESQ., F.R.S.
PROF. A. FOWLER, F.R.S.
LADY LOCKYER, *Assistant Hon. Treasurer.*
DR. W. H. MAW.
LIEUT.-COL. F. K. MCCLEAN, A.F.C.
ROBERT MOND, ESQ., *Chairman of Corporation.*
LIEUT.-COL. W. A. J. O'MEARA, R.E., C.M.G.
SIR NAPIER SHAW, F.R.S.
W. HUBERT SMITH, ESQ., *Hon. Legal Adviser.*

Hon. Secretary :
CAPT. W. N. MCCLEAN,
1, Onslow Gardens, London, S.W.

Asst. Hon. Secretary :
MISS W. L. LOCKYER,
Norman Lockyer Observatory.

In addition to the ordinary members of the Corporation, a number of distinguished foreign astronomers have been asked and accepted the invitation to become foreign members. These are now as follows :

Foreign Members.

Prof. W. S. Adams ..	Mount Wilson Observatory, Pasadena, California, U.S.A.
Prof. A. Bélopolsky ..	Directeur de l'Observatoire, Central Nicholas, Pulkowa, Russia.
Prof. W. W. Campbell ..	Director of the Lick Observatory, Mount Hamilton, California, U.S.A.
Dr. H. A. Deslandres ..	Directeur de l'Observatoire, Meudon, Seine-et-Oise, France.
Prof. E. B. Frost ..	Director of the Yerkes Observatory, Williams Bay, Wisconsin, U.S.A.
Dr. G. E. Hale	Director of the Mount Wilson Observatory, Pasadena, California, U.S.A.
Prof. H. N. Russell ..	Director of the Princeton Observatory, Princeton, New Jersey.
Dr. R. S. Woodward ..	President of the Carnegie Institution of Washington.

In order to obtain advice on the present and future work of the Observatory it was considered advisable to form, if possible, a committee of representative British astronomers to act in this capacity. The result has been the formation of a Research Committee of the following eminent astronomers :—

Research Committee.

Sir Frank Dyson, F.R.S...	Astronomer Royal, Royal Observatory, Greenwich.
Prof. A. S. Eddington, F.R.S.	Plumian Professor of Astronomy, University Observatory, Cambridge.
Prof. A. Fowler, F.R.S. ..	Professor of Astrophysics, Imperial College of Science and Technology, South Kensington.
Prof. H. H. Turner, F.R.S.	Savilian Professor of Astronomy, University Observatory, Oxford.

(15) The Future of the Observatory.

THERE is no doubt that the founders of the Observatory, including many eminent men of science and generous donors, have succeeded in laying out and equipping the Observatory to a very considerable value, and have endowed it with funds of some magnitude, though insufficient for the future. But the good work must not stop here, because further endowment is necessary to place the Observatory on a permanent basis. At the present time the staff is too small, but it is hoped to increase it as the endowment permits, so that it will consist of at least a Director, four assistants, with an attendant and an assistant attendant.

It is much to be lamented that Sir Norman Lockyer, the originator and part founder, passed away just when the Observatory had recommenced work after the war, but it is up to us to endow the Observatory in such a manner that it will be a lasting memorial to him who did so much to promote British Astronomical Science.

The name of the Observatory was originally "The Hill Observatory," but the Corporation Council in 1921 changed it to "The Norman Lockyer Observatory" as a fitting reminder of the great work which he accomplished in the realm of Astrophysics, and his great desire that such work should be continued at the Observatory which he had so much at heart.

The Observatory can continue to accomplish useful work for some time longer, but it is hoped that additional revenue will be forthcoming, so that with larger staff and equipment the full benefit of the position may be secured.